MOHAVE GROUND SQUIRREL RESEARCH AND MONITORING PROGRAM

MONITORING MOHAVE GROUND SQUIRREL POPULATIONS IN THE COSO REGION

2013

PREPARED FOR: CALIFORNIA DEPARTMENT OF FISH & WILDLIFE
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ABSTRACT

Mohave ground squirrel (*Xerospermophilus mohavensis*) populations were monitored in April 2013 at two study sites in the Coso Range of southwestern Inyo County, California. These sites have been protected from human impacts since 1990, so population trends here should reflect the influence of natural environmental forces. Live-trapping was carried out on 25-hectare grids for 5 days and the number of captures was used as an indication of abundance. Six adult Mohave ground squirrels were captured at Coso Basin (Study Site 2) in 2013, while 19 individuals were trapped at Cactus Peak (Study Site 3). Mohave ground squirrel abundance was down sharply from 2012, when numbers were by far the highest recorded since the current monitoring program began in 2001. The extraordinary abundance recorded in 2012 apparently resulted from a four-year sequence of winters (2007-08 to 2010-11) with high and steadily increasing rainfall. However, rainfall during the 2011-12 winter was considerably below the threshold for Mohave ground squirrel reproduction and none of the adult Mohave ground squirrels captured in April 2012 were in reproductive condition. There was even less precipitation during the winter of 2012-13, resulting in complete reproductive failure for a second year. Adult abundance in spring 2014 is predicted to be significantly lower again. These results extend the only long-term record of population trends for the Mohave ground squirrel and demonstrate the great importance of winter rainfall to sustaining viable populations in this species. Data from the Coso study can also provide a helpful perspective on the results from short-term surveys elsewhere. It is recommended that funding be provided to continue this unique record.

INTRODUCTION AND BACKGROUND

This report presents the 2013 results of a long-term monitoring study of Mohave ground squirrel (*Xerospermophilus mohavensis*) populations at two sites in the Coso Range, Inyo County, California. This study is a component of the Mohave Ground Squirrel Research and Monitoring Program that has been funded by California Department of Fish and Game (now California Department of Fish and Wildlife or CDFW) since 2002.

The Coso Range is located in southwestern Inyo County on military lands managed as part of the China Lake Naval Air Weapons Station (China Lake NAWS). It has been known for over 30 years that this area supports relatively abundant and widespread populations of the Mohave ground squirrel (Leitner, 1980; Zembal and Gall, 1980). During the 1980s, development of geothermal resources in the Coso Range for electric power generation raised concerns about potential impacts to this State-listed species. In 1988, geothermal developers, China Lake NAWS, U.S. Bureau of Land Management (BLM), and CDFW adopted a comprehensive mitigation plan to address these impacts.

The Coso Mohave Ground Squirrel Mitigation Program consisted of several elements, including establishment of a livestock exclosure covering about 165 km^2 (64 mi^2) of the Coso Range. Cattle grazing was eliminated from this area in December 1990 to benefit wildlife and particularly Mohave ground squirrel populations. The program also called for monitoring (Coso Grazing Exclosure Study) to evaluate the effects of the grazing exclosure on Mohave ground squirrel abundance. Four study sites were selected and trapping studies

initiated in May and June 1988. Monitoring efforts continued in early summer at these four sites through 1996. In 1990, a spring sampling period (15 March-15 April) was added and spring trapping was also conducted from 1992-1996. Major findings of this nine-year program are summarized in Leitner and Leitner (1998).

During the period from 1997 through 2000, no funding was available to continue systematic monitoring of Mohave ground squirrel abundance on the four original study sites. However, a radio-telemetry study of adult and juvenile Mohave ground squirrel movements was carried out at Study Site 3 (Cactus Peak) from February through August 1997, along with trapping and marking for estimation of population size. Live trapping was also carried out in March-April 1998 and again in April and June 2000 (Leitner, 2001b) to determine Mohave ground squirrel abundance at the Cactus Peak study site. There are no data for 1999.

Regulatory requirements on the operator of the Coso geothermal power plants were modified by the California Energy Commission in 1997. The geothermal operator (Coso Operating Company LLC) is now required to monitor the status of Mohave ground squirrel populations every five years at two of the Coso Grazing Exclosure sites. Coso Basin (Study Site 2) and Cactus Peak (Study Site 3) were chosen because they appeared to have the best quality habitat and generally supported the most abundant Mohave ground squirrel populations during the nine years of the Coso Grazing Exclosure Study (1988-1996). The first monitoring effort under this new program was conducted in March-April 2001 (Leitner, 2001a). Monitoring funded by Coso Operating Company LLC was carried out again in March 2006 and 2011 (Leitner, 2006 and 2011).

The study described in this report was designed to complement the monitoring effort conducted every five years by the Coso geothermal operator. Such continued monitoring was first recommended in December 1999 by the Mohave Ground Squirrel Technical Advisory Group (TAG), an organization made up of scientists and agency staff that advises CDFW on conservation and management of the Mohave ground squirrel. In late 2001, CDFW provided funds for spring monitoring of Mohave ground squirrel populations at the Coso Basin and Cactus Peak study sites. This work was conducted from 2002-2005 and again from 2007-2010 through CDFW contracts with the Endangered Species Recovery Program at California State University, Stanislaus. In 2012, project expenses were reimbursed by CDFW.

The purpose of this monitoring effort is to maintain the only long-term record of abundance for the Mohave ground squirrel. The Coso study sites are in relatively undisturbed habitat protected from urban development, livestock grazing, and OHV recreation. The data from long-term monitoring at these sites can show the response of Mohave ground squirrel populations to natural environmental changes such as annual variation in winter rainfall. They can also serve as indicators of the health and viability of Mohave ground squirrel populations in the northern part of the range. Finally, they can provide a reference point for evaluating population data from short-term studies in other parts of the Mohave ground squirrel range.

METHODS

DESCRIPTION OF STUDY SITES

The locations of the two study sites at which monitoring was carried out are shown in Figure 1. Both the Coso Basin (Study Site 2) and Cactus Peak (Study Site 3) monitoring plots are within the Coso Grazing Exclosure established in December 1990. They have not been grazed by domestic livestock since 1990. These sites are within the military reservation managed by China Lake NAWS for weapons testing activities, but have been reserved exclusively for biological monitoring and research since 1990. The legal description of each site is as follows:

Coso Basin: T22S R39E, SE ¼ Sec. 3 and NE ¼ Sec. 10, MDB&M
Cactus Peak: T21S R39E, SE ¼ Sec. 30, MDB&M

The Coso Basin study site is southeast of Coso Hot Springs at an elevation of 1085 meters (3580 feet). The natural community is Mojave Mixed Woody Scrub, a diverse mixture of shrubs including shadscale (*Atriplex confertifolia*), goldenhead (*Acamptopappus sphaerocephalus*), and Mormon-tea (*Ephedra nevadensis*), among others. The western edge of this site contains a narrow strip of Mojave Desert Wash Scrub, a rich mixture of deep-rooted perennials.

The Cactus Peak study site is located southeast of Cactus Peak in a large upland basin at an elevation of 1470 m (4840 ft). The vegetation consists of the bajada phase Mojave Mixed Woody Scrub grading into Desert Saltbush Scrub in the lowest portions of the basin. Important shrub species are spiny hopsage (*Grayia spinosa*), fourwing saltbush (*Atriplex canescens*), and shadscale with scattered Joshua trees (*Yucca brevifolia*).

LIVE-TRAPPING PROCEDURES

The abundance of Mohave ground squirrels on each of the study sites was determined using a standard live-trapping technique. The trapping grids established during the Coso Grazing Exclosure Study (1988-1996) were employed for this mark-recapture sampling procedure. Each grid measured 500 by 500 m (1640 x 1640 ft) and included an area of 25 hectares (62 acres). A total of 441 traps were placed at 25 m intervals on each grid in a 21 x 21 array. Two types of traps were employed at each grid. Pymatuning traps made up 81 percent (357 traps) of the total, while the remaining 19 percent consisted of Sherman traps. Pymatuning traps (10 x 10.5 x 39 cm) have wire mesh sides and back, while the tops, bottoms, and door are solid sheet metal. Sherman traps are smaller (8 x 9 x 23 cm) and are made entirely of sheet aluminum.

Monitoring was carried out during early April 2013 (Table 1). Traps were pre-baited for two days, followed by 5 days of trapping. Trapping effort at the Cactus Peak study site was slightly reduced in 2013 because of the threat of predation on trapped animals by common ravens (*Corvus corax*). Sixty-three traps in the area with highest raven activity were not opened. The bait used was a commercial livestock feed that included rolled oats, rolled barley, cracked corn, and molasses. Traps were placed beside or under shrubs within 1-3 m (3-10 ft) of the wooden stakes that marked the trap stations. Traps were opened in the morning between 0800 and 1000 hours and closed in the afternoon between 1600 and 1800 hours. They were checked twice each day on a regular schedule.

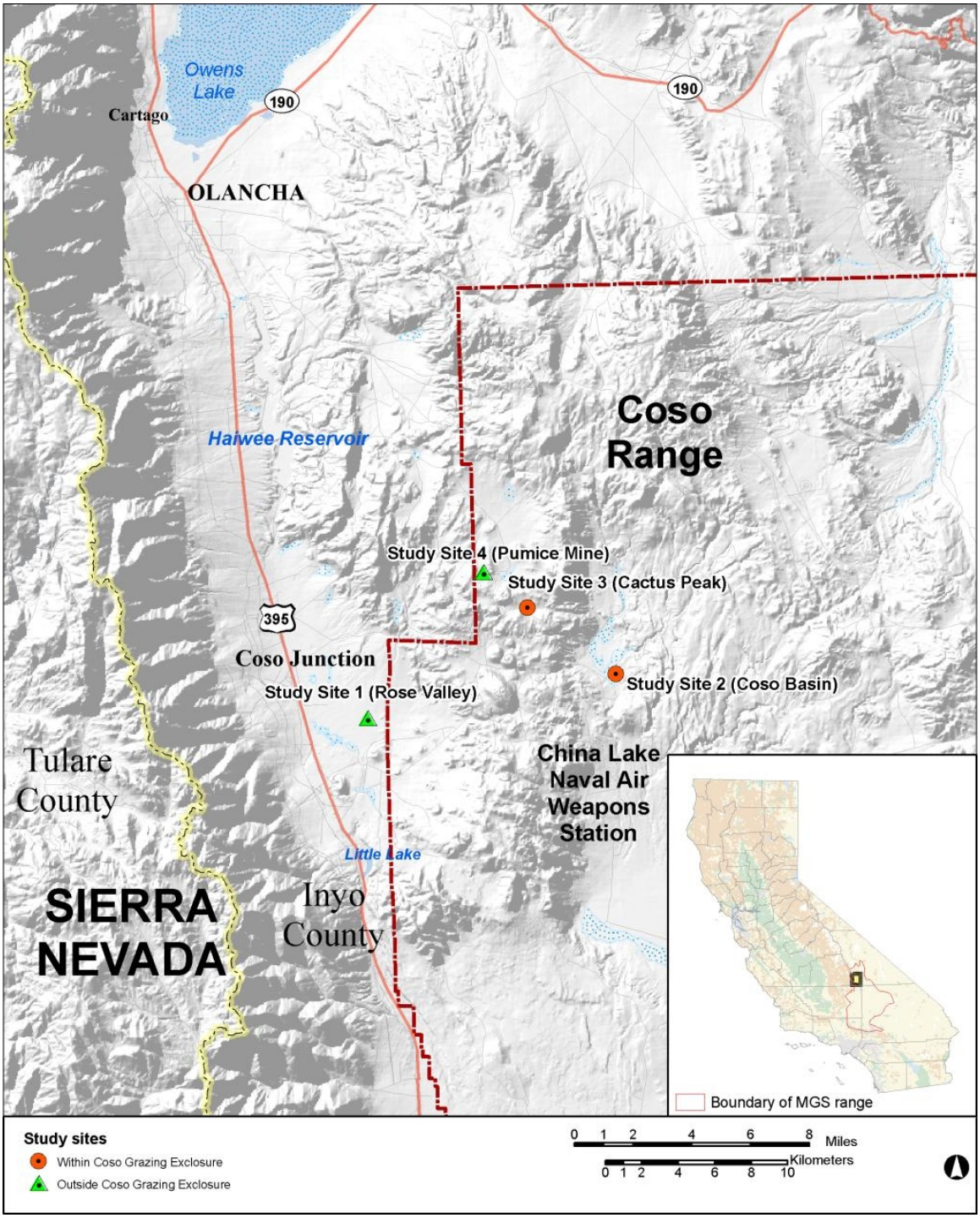

Figure 1. Map of the Coso region in southwestern Inyo County, California, showing the locations of Mohave ground squirrel monitoring sites. Field studies were carried out at Study Sites 1 (Rose Valley) and 4 (Pumice Mine) from 1988 through 1996. No studies have been conducted at these sites in recent years, with the exception of the Rose Valley study site in 2010.

Table 1. Trapping dates at the Coso Basin and Cactus Peak study sites during spring monitoring in 2013. Trapping effort consisted of 2205 trap-days at Coso Basin and 1890 trap-days at Cactus Peak over the five-day period.

Study Site	Trapping Period
Coso Basin	5-9 April
Cactus Peak	5-9 April

All captured ground squirrels were identified to species; both Mohave ground squirrels and white-tailed antelope squirrels (*Ammospermophilus leucurus*) were captured on each grid. Sex, reproductive status, and age class (adult/juvenile) were recorded for both species. A 300 g (12 oz) capacity Pesola® spring scale was used to determine body mass of Mohave ground squirrels upon first capture. All Mohave ground squirrels were permanently marked for individual identification with a passive integrated transponder (PIT) tag (BioSonics® 400 kHz or Biomark® 125 kHz). The tags were implanted subcutaneously between the shoulder blades using a veterinary syringe and 12-gauge needle. Ground squirrels of both species were marked on the ventral surface with a colored felt marking pen so that they could be recognized as recaptures if trapped later in the same sampling period. All data were recorded on standard field data forms and the animal then released unharmed at the place of capture.

PRECIPITATION DATA

No precipitation data were collected at the two study sites during the 2013 period. For many years, the Geothermal Program Office at China Lake NAWS has operated five tipping bucket rain gauges in Coso Basin and has provided winter rainfall data for this study. Unfortunately, these rain gauges ceased operation during summer 2008 and no data are available for Coso Basin since that time. However, winter rainfall records were obtained from the weather stations at Haiwee Dam and Haiwee Power Plant. These stations are operated by the Los Angeles Department of Water and Power and are located about 14-18 km (9-11 mi) NW of the Coso Basin and Cactus Peak study sites. Figure 2 shows the locations of these weather stations in relation to the Mohave ground squirrel monitoring sites.

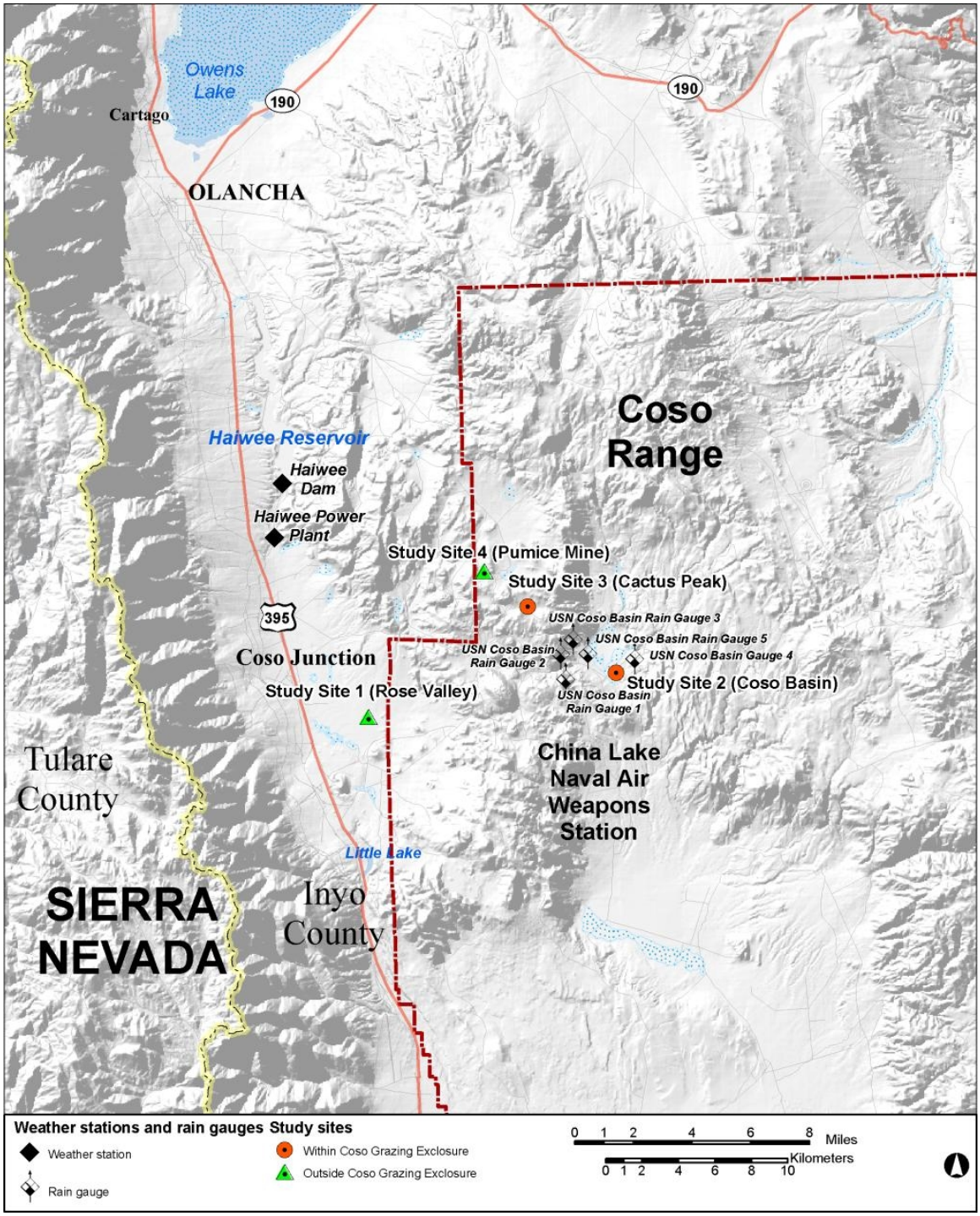

Figure 2. Map of the Coso region in southwestern Inyo County, California, showing the locations of the Haiwee Dam and Haiwee Power Plant weather stations and the former US Navy rain gauges in Coso Basin in relation to the Coso Basin and Cactus Peak study sites.

RESULTS

Mohave ground squirrel abundance was estimated from the total number of individuals captured during the five-day trapping period at each study site.

COSO BASIN (STUDY SITE 2)

Table 2 shows the numbers of Mohave ground squirrels and white-tailed antelope squirrels trapped on the Coso Basin study site during the April 5-9 sampling period by species, sex, and age class. Five days of trapping (2,205 trap-days) resulted in the capture of 6 Mohave ground squirrels and 12 white-tailed antelope squirrels. Five of the Mohave ground squirrels were recaptured, several multiple times, giving a total of 19 Mohave ground squirrel captures. The total number of white-tailed antelope squirrel captures was 28. All ground squirrels captured were adults.

Table 2. Summary of trapping results at Coso Basin (Study Site 2) by species, sex and age of animal during April 5-9, 2013. Trapping conducted with 441 traps at 25 meter spacing in a 21 x 21 trap array.

MOHAVE GROUND SQUIRREL			
	Male	**Female**	**Total**
Juvenile	0	0	0
Adult	2	4	6
Total	2	4	6
WHITE-TAILED ANTELOPE SQUIRREL			
	Male	**Female**	**Total**
Juvenile	0	0	0
Adult	4	8	12
Total	4	8	12

All female Mohave ground squirrels captured at the Coso Basin study site were non-reproductive, showing no evidence of pregnancy or lactation. The male Mohave ground squirrels were also non-reproductive. Female white-tailed antelope squirrels appeared to be non-reproductive, although some males had scrotal testes. Appendix A shows the characteristics of Mohave ground squirrels captured at Coso Basin (Study Site 2) during the period April 5-9, 2013.

CACTUS PEAK (STUDY SITE 3)

Table 3 shows the number of ground squirrels of both species trapped on the Cactus Peak study site during the April 5-9 sampling period by species, sex, and age class. Five days of trapping (1,890 trap-days) resulted in the capture of 19 Mohave ground squirrels and 11 white-tailed antelope squirrels. A total of 33 Mohave ground squirrel and 14 white-tailed

antelope squirrel captures were recorded due to recaptures of several individuals. All animals captured were adults.

Table 3. Summary of trapping results at Cactus Peak (Study Site 3) by species, sex and age of animal during April 5-9, 2013. Trapping conducted with 378 traps at 25 meter spacing in a 21 x 18 trap array.

MOHAVE GROUND SQUIRREL			
	Male	**Female**	**Total**
Juvenile	0	0	0
Adult	4	15	19
Total	4	15	19
WHITE-TAILED ANTELOPE SQUIRREL			
	Male	**Female**	**Total**
Juvenile	0	0	0
Adult	4	7	11
Total	4	7	11

As was the case at the Coso Basin study site, there was no sign of reproductive activity among either male or female Mohave ground squirrels captured at the Cactus Peak study site. Three of the male white-tailed antelope squirrels had scrotal testes, although none of the females appeared to be pregnant or lactating. Appendix B shows the characteristics of Mohave ground squirrels captured at Cactus Peak (Study Site 3) during the period April 5-9, 2013.

DISCUSSION

MONITORING RESULTS IN 2013

In 2013, the numbers of adult Mohave ground squirrels captured at the two Coso sites were sharply lower than in 2012 (Figure 3). The number recorded at Cactus Peak in 2013 was only 29% of the total trapped in 2012, while at Coso Basin only 6 individuals were captured in contrast to 27 in 2012. These results were expected because of low rainfall over the 2011-2012 winter and consequent reproductive failure in the spring of 2012 (Leitner 2012). Adult Mohave ground squirrel abundance at the two sites in 2012 was the highest since the current monitoring program began in 2001. This spike in abundance clearly resulted from four years with winter rainfall above the threshold for reproduction in this species (Figure 3). Mohave ground squirrel reproduction was documented at both study sites from 2008 through 2011, the first time since monitoring began in 1988 that reproduction has been recorded for four consecutive years. The 2012 adult population undoubtedly included many individuals born in 2011, but there was evidently low survival into spring 2013. This would be expected in view of dry conditions and lack of forage during the spring and early summer of 2012.

Rainfall during the 2012-2013 winter was only 34 mm, far below the Mohave ground squirrel reproductive threshold and there was complete absence of annual plant production. It is reasonable to expect that Mohave ground squirrel abundance will be significantly lower at both Coso study sites in 2014.

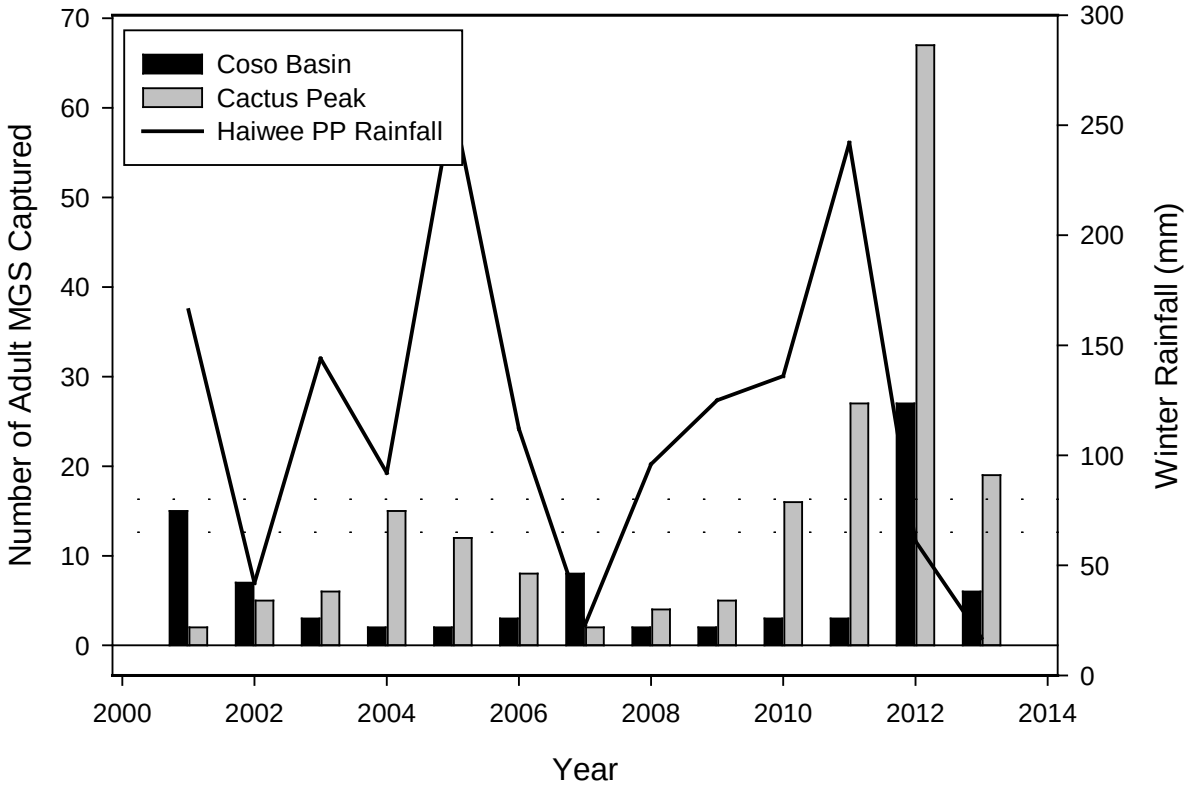

Figure 3. Mohave ground squirrel captures at the Coso Basin and Cactus Peak study sites in March-May during the period 2001-2013. Data are numbers of adults captured over 5 days (4 days at Cactus Peak in 2012) with 2 days of pre-baiting using 441 traps (378 traps at Cactus Peak in 2013) with 25-meter spacing. The solid line indicates winter rainfall (Oct-Mar) as recorded at the Haiwee Power Plant, while the horizontal dashed lines placed at 60 and 85 mm show the approximate range of the winter rainfall threshold for reproduction in the Mohave ground squirrel (Leitner and Leitner 1998).

In 2012, the proportion of unmarked individuals was very high, reaching 93% of all captures at Coso Basin and 77% at Cactus Peak (Leitner 2012). It is very likely that most of these new animals were yearlings born in 2011. The lack of recruitment in 2012 resulted in a much higher percentage of recaptures in 2013 and relatively few unmarked animals (Table 4). It is likely that most of the new captures were adults whose home ranges adjoined the trapping grids in 2012, but who increased their foraging area to intersect the grids in 2013.

Table 4. The numbers of recaptures and new captures of Mohave ground squirrels recorded at the Coso Basin and Cactus Peak study sites in April 2013.

	Total	Recaptures	New Captures
Coso Basin			
Males	2	1	1
Females	4	2	2
Cactus Peak			
Males	4	2	1
Females	15	10	5

Common raven (*Corvus corax*) activity at the Cactus Peak site was somewhat reduced from 2012. Up to 20-25 ravens visited the site daily in 2012, disturbing traps and on one occasion attacking a captured antelope ground squirrel. During the 2013 sampling period, no more than 6-8 ravens were observed on the site at any one time. They appeared to concentrate their activity on the section of the grid with lowest shrub cover. Because of this behavior, the traps in that area were not opened. There was little disturbance of traps elsewhere on the grid and no captured animals were injured. Raven depredation will undoubtedly be an on-going concern in future years at the Cactus Peak site, but was managed successfully in 2013. Raven disturbance has never occurred at the Coso Basin site.

LONG-TERM TRENDS IN MOHAVE GROUND SQUIRREL ABUNDANCE

Monitoring of Mohave ground squirrel populations has been carried out at the Coso Basin and Cactus Peak study sites since 1990 (Figure 4). These data indicate the size of the adult population in spring following emergence from dormancy. Although there are gaps in the record (1991 and 1997-2000), this is the only long-term data set available for the species.

The abundance of adult Mohave ground squirrels at these two study sites has varied greatly over the past 24 years. Adult numbers were relatively low from 1990 through 1992, followed by a five-year period with much higher numbers. When monitoring was resumed in 2001, abundance was again quite low and remained low through 2009. There was a marked upswing from 2010 to 2012, with numbers of adults matching and even exceeding levels last reached in the early to mid-1990s. A detailed analysis of these abundance patterns makes it clear that Mohave ground squirrel reproduction is closely linked to winter rainfall and spring production of herbaceous forage (Leitner 2012). Reproduction in this species seems to require minimum precipitation during the period Oct. 1-Mar. 31 in the range of 65-80 mm (Leitner and Leitner, 1998).

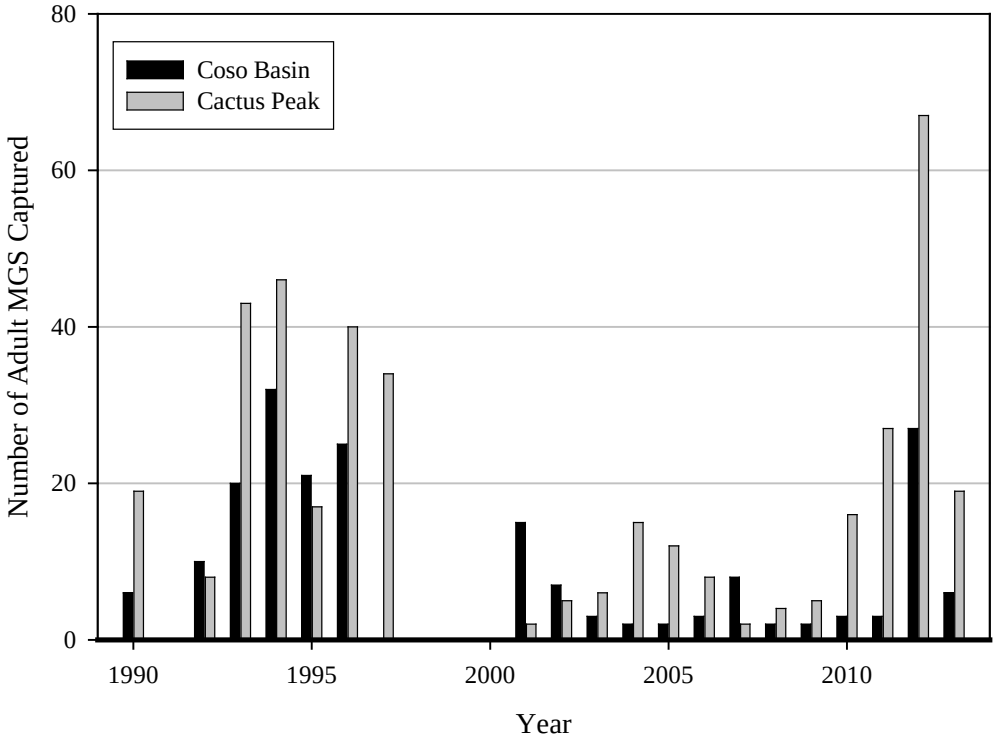

Figure 4. Mohave ground squirrel captures at the Coso Basin and Cactus Peak study sites in March-May during the period 1990-2013. Data are numbers of adults captured over 5 days (4 days at Cactus Peak in 2012) with 2 days of pre-baiting using 441 traps (378 traps at Cactus Peak in 2013) with 25-meter spacing. There are no comparable data available for 1991 and for 1998 through 2000; data for 1997 only for Cactus Peak.

A striking feature of the long-term record of Mohave ground squirrel abundance at the two Coso sites is the clear tendency for adult numbers at Coso Basin to be lower. In 15 of the 20 years for which there are data at both sites, the number of adults at Coso Basin was less than at Cactus Peak. Because of the critical influence of winter rainfall, it seems reasonable to examine precipitation records to see if they can suggest an explanation. Figure 5 shows a 25-year record of winter rainfall (Oct. 1-Mar. 31) as recorded at the Haiwee Dam and Haiwee Power Plant weather stations and data from the China Lake NAWS Coso Basin rain gauges through 2008. Winter rainfall at Haiwee Dam and Haiwee Power Plant varied in a very similar pattern over this entire period, with totals at Haiwee Dam almost always higher. Coso Basin rainfall was generally lower, probably because of the rainshadow effect of the Coso Range to the west.

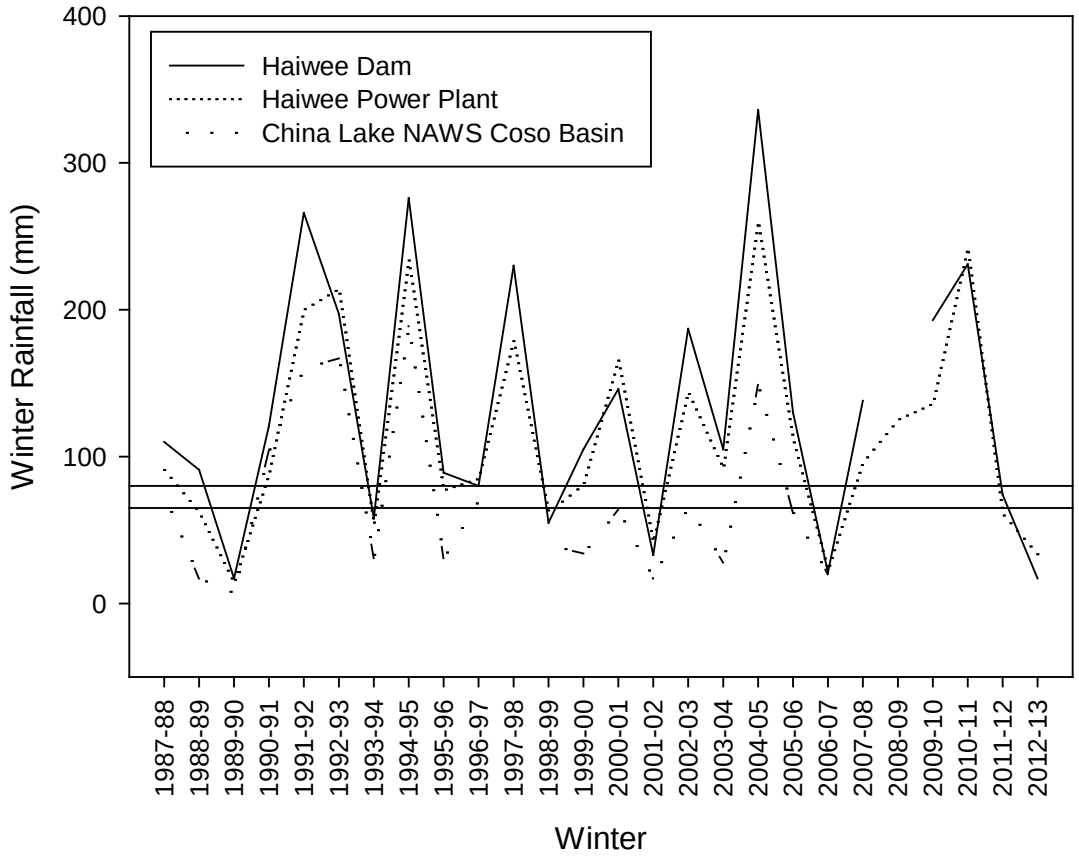

Figure 5. Winter precipitation (Oct. 1 – Mar. 31) during the period 1987-88 through 2012-13 at Haiwee Dam and Haiwee Power Plant and at China Lake NAWS Coso Basin rain gauges. The 2 horizontal lines placed at 65 mm and 80 mm show the approximate range of the winter rainfall threshold for reproduction in the Mohave ground squirrel (Leitner and Leitner 1998).

During the early 1990s, a prolonged El Nino episode brought winter rainfall well above the threshold for Mohave ground squirrel reproduction in 4 of 5 years. Rainfall was relatively low at Coso Basin compared to the Haiwee weather stations, but still more than adequate for reproduction except in 1994. Mohave ground squirrel abundance at the Coso Basin site was relatively high (≥10 adults) during this period of above-average rainfall (Figure 4). However, since 2001 Mohave ground squirrel numbers at Coso Basin have usually been quite low (2-3 adults). Over this more recent period, the China Lake NAWS rain gauges in Coso Basin indicated rainfall close to or below the reproductive threshold during 6 of 7 winters. This low rainfall may be related to the minimal Mohave ground squirrel numbers there during much of that time.

This long-term study has demonstrated that Mohave ground abundance can vary greatly over time in response to winter rainfall patterns. Mohave ground squirrel populations may undergo long periods of low abundance, but several years of high rainfall may result in greatly increased numbers. However, the vulnerability of this species to prolonged drought should be of concern because of the potential impacts of future climate change.

The results of the Coso monitoring study are of particular value because they indicate how Mohave ground squirrel abundance changes over time in response to natural environmental factors. Both Coso study sites have been free of human impacts since 1990, when livestock grazing was removed. There has been no surface disturbance or change in soils or vegetation due to human activity over the past 23 years. Any trends in abundance as shown by changes in number of captures should therefore reflect natural environmental processes.

RECOMMENDATIONS

The Coso monitoring study has been successful in demonstrating the importance of winter rainfall to reproduction and survivorship of Mohave ground squirrel populations. These results suggest that the protection of other areas within the range of the species that can support Mohave ground squirrel populations during low rainfall episodes may be a critical conservation measure. This information will also be valuable for the interpretation of any temporal trends in the distribution and abundance of Mohave ground squirrels that may be revealed by future range-wide monitoring efforts. It is essential to maintain this unique long-term data base. It is recommended that CDFW continue to fund this study at the 2 Coso sites.

ACKNOWLEDGEMENTS

The enthusiasm and hard work of the field crew was very much appreciated. Field workers included a number of volunteers, whose participation made the 2013 study possible. The Environmental Office at China Lake NAWS granted access to the Coso study area and provided badges for project personnel. The Los Angeles Department of Water and Power provided precipitation data collected by their personnel at the Haiwee Power Plant. Funding for project expenses was arranged by the CDFW Bishop Field Office. Trapping and marking Mohave ground squirrels was conducted under authority of a Memorandum of Understanding with CDFW.

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APPENDIX A. CHARACTERISTICS OF MOHAVE GROUND SQUIRRELS CAPTURED AT COSO BASIN (STUDY SITE 2) DURING THE PERIOD APRIL 5-9, 2013.

PIT Tag Number	Sex	Reproductive Condition	Body Mass
0A130A292C	F	Non-reproductive	98
0A130A2870	F	Non-reproductive	99
0A140A5452	F	Non-reproductive	109
0A140A5523	F	Non-reproductive	124
1F653D023D	M	Testes non-scrotal	94
0A140A5422	M	Testes non-scrotal	120

APPENDIX B. CHARACTERISTICS OF MOHAVE GROUND SQUIRRELS CAPTURED AT CACTUS PEAK (STUDY SITE 3) DURING THE PERIOD APRIL 5-9, 2013.

PIT Tag Number	Sex	Reproductive Condition	Body Mass
0A130A291A	F	Non-reproductive	120
1F6669050D	F	Non-reproductive	144
1F654E406E	F	Non-reproductive	125
1F64334F7B	F	Non-reproductive	114
0A130A286A	F	Non-reproductive	90
1F62026A13	F	Non-reproductive	102
0A130A2923	F	Non-reproductive	103
1F65327F4B	F	Non-reproductive	122
0A140A5459	F	Non-reproductive	108
1F63714A43	F	Non-reproductive	--
1F64536149	F	Non-reproductive	89
1F6429765E	F	Non-reproductive	116
0A130A2926	F	Non-reproductive	108
0A130A293E	F	Non-reproductive	116
0A140A547B	F	Non-reproductive	96
0A130A2919	M	Testes non-scrotal	124
0A130A2917	M	Testes non-scrotal	144
1F61162545	M	Testes non-scrotal	150
0A140A5463	M	Testes non-scrotal	138